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TECHNICAL MEMORANDUM

TO: Timothy Brincefield, EPA Region 10

FROM: Gordon Randall, Ecology and Environment, Inc., Seattle, Washington

THRU: Dhroov Shivjani, Ecology and Environment, Inc., Seattle, Washington

DATE: January 20, 1997

RE: Contract No. 68-W9-0020, WA No. 20-38-OPD4.

SUBJECT: Risk Calculations for Agricultural Workers at Monsanto

The objective of this technical memorandum is to evaluate potential carcinogenic risks and non-cancer health hazards to agricultural workers laboring near the Monsanto Chemical Company (MCC) Soda Springs Elemental Phosphorus Plant. This technical memorandum is intended to supplement the baseline human health risk assessment for the MCC Plant (EPA 1995a). A full discussion of the risk assessment process and the methodology used is presented in the baseline risk assessment; this technical memorandum only lists differences from the assumptions used in the baseline.

1. Exposure Assessment

The following exposure pathways were evaluated for the agricultural worker scenario: soil ingestion, inhalation of particulates in air, and external gamma exposure. Several assumptions were made for this scenario that deviate from standard EPA, Region 10, defaults for industrial receptors. As directed by EPA (EPA 1997), agricultural workers were assumed to be present for 12 hours per day and 185 days per year. These receptors were assumed to ingest 100 mg/day of soil, representing 100% of the default adult incidental soil ingestion rate. An inhalation rate of 30 m³/day was used, representing 12 hours of moderate activity. Agricultural workers were assumed to be unshielded from external gamma radiation.

Exposure parameters for this scenario are summarized in Table 1-1. The calculations that use these parameters to estimate intake are presented in Table 1-2.

EPA (1997) directed E & E to evaluate the agricultural worker scenario at the North I and North II offsite future residential locations from the baseline risk assessment. Exposure point concentrations for contaminants in air and soil at these locations are presented in Table 1-3.

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2. Toxicity Assessment

Since the baseline risk assessment was prepared, the slope factors for radionuclides have been revised. The current values, presented in HEAST (EPA 1995b), frequently vary from the older values by a significant amount. The most recent toxicity values were used to calculate risks in this technical memorandum. A comparison of the old and new slope factors is presented in Table 2-1.

Risks for the future RME residential scenario at the North I and North II locations were recalculated using the new toxicity values. These results are presented in Table 2-2. Although many of the risks associated with individual pathways and contaminants have changed, the total risk does not change significantly. This is because of the comparatively small change to the slope factor of the primary risk driver, external exposure to Radium-226+D.

3. Risk Characterization

Table 3-1 presents the estimated excess lifetime cancer risks and non-cancer hazard quotients for the agricultural worker scenario. Table 3-2 shows the details of the risk calculations by pathway.

North I Location. The total excess lifetime cancer risks associated with potential exposure to metals was $3\text{E-}5$; ingestion of arsenic ($2\text{E-}5$) was the primary contributor to the total risk estimate. The total excess lifetime cancer risks associated with potential exposure to radionuclides was $6\text{E-}4$; external exposure to radium-226+D ($6\text{E-}4$) was the primary contributor to the total risk estimate. Hazard quotients were below 1 for all pathways.

North II Location. The total excess lifetime cancer risks associated with potential exposure to metals was $7\text{E-}6$; ingestion of arsenic ($5\text{E-}6$) was the primary contributor to the total risk estimate. The total excess lifetime cancer risks associated with potential exposure to radionuclides was $1\text{E-}4$; external exposure to radium-226+D ($1\text{E-}4$) was the primary contributor to the total risk estimate. Hazard quotients were below 1 for all pathways.

Background. Excess lifetime cancer risks at the background location were calculated at the background location. Table 3-3 presents the incremental risk over background for the North I and North II locations. Table 3-4 shows the details of the background risk calculations. Risks associated with ingestion of metals and exposure to radionuclides exceeded background at both locations; incremental risks were highest at the North I location.

4. Summary and Conclusions

Excess lifetime cancer risks associated with exposure to metals and radionuclides exceeded background at both the North I and North II locations. External exposure to Radium-226+D was the primary contributor to risks at both locations. This pathway yielded risks of $6\text{E-}4$ at the North I location and $1\text{E-}4$ at the North II location.

Table 4-1 presents a comparison of risks for the agricultural worker scenario and the future RME residential scenario presented in the baseline risk assessment (EPA 1995a). Excess lifetime cancer risks associated with exposure to radionuclides are about one third as high in the agricultural worker scenario as in the residential scenario; risks associated with ingestion and inhalation of metals are about one fifth as high in the agricultural worker scenario as in the residential scenario.

References

United States Environmental Protection Agency (EPA), 1995a, *Baseline Human Health and Ecological Risk Assessments For Monsanto Chemical Corporation Superfund Site, Soda Springs, Idaho*, Seattle, Washington.

EPA, 1995b, *Health Effects Assessment Summary Table, Annual Update FY 1995*, Office of Solid Waste and Emergency Response (OSWER), Washington, D.C.

EPA, 1997, personal communication from Timothy Brincefield to Dhroov Shivjiani at Ecology and Environment, Inc., Seattle, Washington.

Table 1-1
Agricultural Worker Scenario Exposure Factors

Exposure Route	RME Exposure Factors	
	Noncarcinogens	Carcinogens
Soil Ingestion		
Ingestion Rate (mg/day)	100	100
Exposure Frequency (days/year)	185	185
Exposure Duration (years)	25	25
Body Weight (kg)	70	70
Averaging Time (days) ^a	9,125	25,550
Dust Inhalation		
Inhalation Rate (m ³ /day)	30	30
Exposure Frequency (days/year)	185	185
Exposure Duration (years)	25	25
Body Weight (kg)	70	70
Averaging Time (days) ^a	9,125	25,550
External Exposure to Radionuclides		
Gamma Shielding Factor (unitless)	NA	0.0(b)
Gamma Exposure Factor (unitless)	NA	0.25(c)
Exposure Duration (years)	NA	25
<p>(a) Averaging time for noncarcinogens is the exposure duration x 365 days/yr. For carcinogens it is 70 years x 365 days/year.</p> <p>(b) Workers assumed to be unshielded in the agricultural worker scenario.</p> <p>(c) Gamma factor derived: $((12 \text{ h/d} \times 185 \text{ d/yr} \times 25 \text{ yr}) / (24 \text{ h/d} \times 365 \text{ d/yr} \times 25 \text{ yr}))$</p> <p>NA = not applicable</p>		

Table 1-2
Calculation of Intake and Exposure Factors for the
Agricultural Worker Scenario

Calculation of Oral Intake Factor (inorganics in soils)

$$\text{Intake Factor} = (\text{Ingestion Rate} \times \text{Exposure Frequency} \times \text{Exposure Duration}) / (\text{Averaging Time} \times \text{Body Weight} \times 10^6 \text{ mg/kg})$$

Hazard or Risk	Ingestion Rate (mg/d)	Exposure Frequency (d/yr)	Exposure Duration (yr)	Averaging Time (d)	Body Weight (kg)	RME Intake Factor (1/d)
Non-cancer	100	185	25	9,125	70	1.3E-07
Cancer	100	185	25	25,550	70	2.6E-07

Calculation of Oral Intake Factor (radionuclides in soil)

$$\text{Intake Factor} = \text{Ingestion Rate} \times \text{Exposure Frequency} \times \text{Exposure Duration} \times \text{Conversion Factor}$$

Hazard or Risk	Ingestion Rate (mg/d)	Exposure Frequency (d/yr)	Exposure Duration (yr)	Conversion Factor (g/mg)	RME Intake Factor (1/d)
Cancer	100	185	25	0.001	462.5

Calculation of External Exposure Factor (radionuclides)

$$\text{Exposure Factor} = \text{Exposure Duration} \times (1 - \text{Gamma Shielding Factor}) \times \text{Gamma Exposure Factor}$$

Hazard or Risk	Exposure Duration (yr)	Gamma Shielding Factor	Gamma Exposure Time factor	Exposure Factor (yr)
Cancer	25	0(a)	0.25(b)	6.34

Calculation of Inhalation Intake Factor (inorganics in air)

$$\text{Intake Factor} = (\text{Inhalation Rate} \times \text{Exposure Frequency} \times \text{Exposure Duration}) / (\text{Averaging Time} \times \text{Body Weight})$$

Hazard or Risk	Inhalation Rate (m ³ /d)	Exposure Frequency (d/yr)	Exposure Duration (yr)	Averaging Time (d)	Body Weight (kg)	RME Intake Factor (m ³ /kg-d)
Non-cancer	30	185	25	9,125	70	0.37
Cancer	30	185	25	25,550	70	0.078

Calculation of Inhalation Intake Factors (radionuclides in air)

$$\text{Intake Factor} = \text{Exposure Duration} \times \text{Exposure Frequency} \times \text{Inhalation Rate}$$

Hazard or Risk	Exposure Duration (yr)	Exposure Frequency (d/yr)	Inhalation Rate (m ³ /d)	RME Intake Factor (m ³)
Cancer	25	185(d)	30	138,750

Shading highlights the calculated values

(a) Workers assumed to be unshielded in the agricultural worker scenario.

(b) Gamma factor derived: $((12 \text{ h/d} \times 185 \text{ d/yr} \times 25 \text{ yr}) / (24 \text{ h/d} \times 365 \text{ d/yr} \times 25 \text{ yr}))$

Table 1-3
Exposure Point Concentrations
Agricultural Worker Scenario

Soils (mg/kg or pCi/g)			Background (soil UCL)
COC	North II	North I	
Arsenic	10.4	34	4.4
Beryllium	1.4	3.7	1.2
Cadmium	16.1	153	2.1
Vanadium	68.3	371	25.8
Lead-210+D	6.9	65	2.5
Radium-226+D	2.5	13	1.9
Thorium-230	3.1	12	1.4
Uranium-238+D	2.8	11	1.7

Air (mg/m ³ or pCi/m ³)		
COC	North II	North I
Arsenic	4.0E-08	9.3E-07
Beryllium	6.7E-09	1.5E-07
Cadmium	5.1E-07	1.2E-05
Vanadium	1.0E-06	2.0E-05
Lead-210+D	1.5E-04	2.9E-03
Radium-226+D	2.3E-05	3.9E-04
Thorium-230	2.5E-05	4.4E-04
Uranium-238+D	2.4E-05	4.4E-04

Table 2-1
Comparison of Radionuclide Slope Factors

Radionuclide	Slope Factors used in Baseline Human Health Risk Assessment			Slope Factors used in current evaluation		
	From HEAST, 1994			From HEAST, 1995		
	Oral SF (risk/pCi)	Inhal. SF (risk/pCi)	Extern. SF (risk/yr/pCi/g)	Oral SF (risk/pCi)	Inhal. SF (risk/pCi)	Extern. SF (risk/yr/pCi/g)
Lead-210+D	6.6E-10	4.0E-09	1.6E-10	1.1E-09	3.9E-09	1.3E-10
Radium-226+D	1.2E-10	3.0E-09	6.0E-06	3.0E-10	2.8E-09	6.7E-06
Thorium-230	1.3E-11	2.9E-08	5.4E-11	3.8E-11	1.7E-08	4.4E-11
Uranium-238+D	2.0E-11	2.4E-08	5.1E-08	6.2E-11	1.2E-08	5.3E-08

Table 2-2
Comparison of Future RME Residential Risks

North I	Risks calculated in Baseline Risk Assessment				Risks calculated using current slope factors			
	Ingestion	External	Inhalation	Total	Ingestion	External	Inhalation	Total
Lead-210+D	5E-5	2E-7	2E-6	6E-5	9E-5	2E-7	2E-6	9E-5
Radium-226+D	2E-6	2E-3	2E-7	2E-3	5E-6	2E-3	2E-7	2E-3
Thorium-230	2E-7	2E-8	3E-6	3E-6	6E-7	1E-8	2E-6	2E-6
Uranium-238+D	3E-7	1E-5	2E-6	2E-5	9E-7	1E-5	1E-6	2E-5
Totals	6E-5	2E-3	8E-6	2E-3	1E-4	2E-3	5E-6	2E-3
North II								
Lead-210+D	6E-6	3E-8	1E-7	6E-6	9E-6	2E-8	1E-7	1E-5
Radium-226+D	4E-7	4E-4	1E-8	4E-4	9E-7	4E-4	1E-8	4E-4
Thorium-230	5E-8	4E-9	2E-7	2E-7	1E-7	3E-9	9E-8	2E-7
Uranium-238+D	7E-8	3E-6	1E-7	4E-6	2E-7	4E-6	6E-8	4E-6
Totals	6E-6	4E-4	4E-7	4E-4	1E-5	4E-4	3E-7	4E-4
Shading indicates Total Risk from all chemicals and pathways.								

Table 3-1
Agricultural Worker Scenario
Risks at North I

Contaminant of Concern	Cancer Risks			
	Ingestion	External	Inhalation	TOTAL RISK
Arsenic	2E-5	--	4E-6	2E-5
Beryllium	4E-6	--	9E-8	4E-6
Cadmium	--	--	6E-6	6E-6
Pathway Risk	2E-5	--	9E-6	3E-5
RADIONUCLIDES				
Lead-210+D	3E-5	6E-8	2E-6	3E-5
Radium-226+D	2E-6	6E-4	1E-7	6E-4
Thorium-230	2E-7	3E-9	1E-6	1E-6
Uranium-238+D	3E-7	4E-6	8E-7	5E-6
Pathway Risk	4E-5	6E-4	4E-6	6E-4

Shading indicates Total Risk from all chemicals and pathways.

Table 3-1 (continued)
Agricultural Worker Scenario
Risks at North II

Contaminant of Concern	Cancer Risks			
	Ingestion	External	Inhalation	TOTAL RISK
Arsenic	5E-6	--	2E-7	5E-6
Beryllium	2E-6	--	4E-9	2E-6
Cadmium	--	--	2E-7	2E-7
Pathway Risk	6E-6	--	4E-7	7E-6
RADIONUCLIDES				
Lead-210+D	3E-6	6E-9	8E-8	4E-6
Radium-226+D	3E-7	1E-4	9E-9	1E-4
Thorium-230	5E-8	9E-10	6E-8	1E-7
Uranium-238+D	8E-8	9E-7	4E-8	1E-6
Pathway Risk	4E-6	1E-4	2E-7	1E-4

Shading indicates Total Risk from all chemicals and pathways.

Table 3-2
Calculation^a of Hazards and Risks
Agricultural Worker Scenario

COC	Concentration		Factors (Table 1-2)					Reference Doses (RfD) and Slope Factors (SF)				Hazard Quotients and Cancer Risks				
			Oral Intake			External Exposure	Inhalation Intake	Non-Cancer RfDs	Cancer - Metals/Rads SFs			Hazard Quotient	Cancer Risk			
			Metals		Radionuclides				SFs							
	Source	Air	Non-Cancer	Cancer	Cancer	Cancer	Cancer	Oral RfD	Oral	External	Inhalation		Ingestion	External	Inhalation	TOTAL
NOXIOUS II																
Arsenic	10	4E-08	7.2E-07	2.6E-07	--	--	7.8E-02	3.0E-04	1.8E+00	--	5.0E+01	2.5E-02	4.7E-06	--	1.5E-07	4.9E-06
Beryllium	1.4	7E-09	7.2E-07	2.6E-07	--	--	7.8E-02	5.0E-03	4.3E+00	--	8.4E+00	2.0E-04	1.6E-06	--	4.4E-09	1.6E-06
Cadmium	16	5E-07	7.2E-07	2.6E-07	--	--	7.8E-02	1.0E-03	--	--	6.1E+00	1.2E-02	--	--	2.4E-07	2.4E-07
Vanadium	68	1E-06	7.2E-07	2.6E-07	--	--	7.8E-02	7.0E-03	--	--	--	7.1E-03	--	--	--	--
Pathway Risk													6.3E-06	--	4.0E-07	1.7E-06
RADIONUCLIDES																
Lead-210+D	6.9	1E-04	--	--	4.6E+02	6.3E+00	1.4E+05	--	1.1E-09	1.5E+10	1.9E-09	--	3.5E-06	6.3E-09	7.9E-08	3.6E-06
Radium-226+D	2.5	2E-05	--	--	4.6E+02	6.3E+00	1.4E+05	--	3.0E-10	6.7E-06	2.8E-09	--	3.4E-07	1.1E-04	8.8E-09	1.1E-04
Thorium-230	3.1	2E-05	--	--	4.6E+02	6.3E+00	1.4E+05	--	3.8E-11	4.4E-11	1.7E-08	--	5.4E-08	8.6E-10	5.9E-08	1.1E-07
Uranium-238-D	2.8	2E-05	--	--	4.6E+02	6.3E+00	1.4E+05	--	6.2E-11	5.3E-08	1.2E-08	--	8.0E-08	9.3E-07	4.2E-08	1.1E-06
Pathway Risk													4.0E-06	1.1E-04	1.9E-07	1.1E-04
(a) Units are not shown for concentrations, factors, or toxicity values; units are listed in Table B-3, Appendix A, Section 2.0 of the baseline risk assessment.																

Table 3-2 (continued)
Calculation^a of Hazards and Risks
Agricultural Worker Scenario

COC	Concentration		Factors (Table 1-2)					Reference Doses (RfD) and Slope Factors (SF)				Hazard Quotients and Cancer Risks				
			Oral Intake			External Exposure	Inhalation Intake	Non-Cancer RfDs	Cancer - Metals/Rads SFs			Hazard Quotient	Cancer Risk			
			Metals		Radionuclides				SFs				Ingestion	External	Inhalation	TOTAL
	Source	Air	Non-Cancer	Cancer	Cancer	Cancer	Cancer	Oral RfD	Oral	External	Inhalation					
NORTH																
Arsenic	34	9E-07	7.2E-07	2.6E-07	--	--	7.8E-02	3.0E-04	1.8E+00	--	5.0E+01	8.2E-02	1.5E-05	--	3.6E-06	1.9E-05
Beryllium	4	1E-07	7.2E-07	2.6E-07	--	--	7.8E-02	5.0E-03	4.3E+00	--	8.4E+00	5.4E-04	4.1E-06	--	9.4E-08	4.2E-06
Cadmium	153	1E-05	7.2E-07	2.6E-07	--	--	7.8E-02	1.0E-03	--	--	6.1E+00	1.1E-01	--	--	5.6E-06	5.6E-06
Vanadium	371	2E-05	7.2E-07	2.6E-07	--	--	7.8E-02	7.0E-03	--	--	--	3.8E-02	--	--	--	--
Pathway Risk												2.0E-05	--	9.3E-06	2.9E-05	
RADIONUCLIDES																
Lead-210+D	65	3E-03	--	--	4.6E+02	6.3E+00	1.4E+05	--	1.1E-09	1.5E-10	3.9E-09	--	3.3E-05	6.0E-08	1.6E-06	3.4E-05
Radium-226+D	13	4E-04	--	--	4.6E+02	6.3E+00	1.4E+05	--	3.0E-10	6.7E-06	2.8E-09	--	1.8E-06	5.6E-04	1.5E-07	5.6E-04
Thorium-230	12	4E-04	--	--	4.6E+02	6.3E+00	1.4E+05	--	3.8E-11	4.4E-11	1.7E-08	--	2.1E-07	3.3E-09	1.1E-06	1.3E-06
Uranium-238+D	11	4E-04	--	--	4.6E+02	6.3E+00	1.4E+05	--	6.2E-11	5.3E-08	1.2E-08	--	3.2E-07	3.7E-06	7.6E-07	4.7E-06
Pathway Risk												3.5E-05	5.6E-04	3.5E-06	6.0E-04	

(a) Units are not shown for concentrations, factors, or toxicity values; units are listed in Table B-3, Appendix A, Section 2.0 of the baseline risk assessment.

Table 3-3
Incremental Risk Over Background
Agricultural Worker Scenario

	SCENARIO RISK			
	Site ^a	Background ^b	Ingest, External	Inhalation
NORTH I				
Metals	3E-5	3E-6	3E-5	9E-6
Radionuclides	6E-4	8E-5	5E-4	4E-6
NORTH II				
Metals	7E-6	3E-6	3E-6	4E-7
Radionuclides	1E-4	8E-5	3E-5	2E-7
(a) Includes ingestion, external, and inhalation.				
(b) Includes ingestion and external.				

Table 3-4
Calculation of Hazards and Risks at Background
Agricultural Worker Scenario

COC	Soil Concentration	Factors (Table 1-2)			Reference Doses and Slope Factors			Hazard Quotients and Cancer Risks			
		Oral Intake		External Exposure	Non-Cancer RfDs	Cancer - Metals/Rads SFs		Hazard Quotient	Cancer Risk		
		Non-cancer	Cancer	Cancer	Oral RfD	Oral	External		Oral	External	TOTAL
Arsenic	4.4	7.2E-07	2.6E-07	--	3.0E-04	1.8E+00	--	1.1E-02	2.0E-06	--	2.0E-06
Beryllium	1.2	7.2E-07	2.6E-07	--	5.0E-03	4.3E+00	--	1.7E-04	1.3E-06	--	1.3E-06
Pathway Risk									3.3E-06	--	3.3E-06
Radionuclides											
Lead-210	2.5	--	4.6E+02	6.3E+00	--	1.1E-09	1.5E-10	--	1.3E-06	2.3E-09	1.3E-06
Radium-226	1.9	--	4.6E+02	6.3E+00	--	3.0E-10	6.7E-06	--	2.6E-07	8.1E-05	8.1E-05
Thorium-230	1.4	--	4.6E+02	6.3E+00	--	3.8E-11	4.4E-11	--	2.4E-08	3.9E-10	2.5E-08
Uranium-238+D	1.7	--	4.6E+02	6.3E+00	--	6.2E-11	5.3E-08	--	4.9E-08	5.7E-07	6.1E-07
Pathway Risk									1.5E-06	8.2E-05	8.3E-05
(a) Units are not shown for concentrations, factors, or toxicity values; units are listed in Table B-3, Appendix A, Section 2.0 of the baseline risk assessment.											

Table 4-1 Comparison of Risks for Agricultural Worker Scenario and Future Residential RME Scenario		
	SCENARIO	
	Agricultural Worker	Future Residential RME
NORTH I		
Metals	3E-5	1E-4
Radionuclides	6E-4	2E-3
NORTH II		
Metals	7E-6	4E-5
Radionuclides	1E-4	4E-4